[Proc. Roy. Soc. Victoria, **53** (N.S.), Pt. II., 1941.]

Art. XIII.—*The Volcanoes of the Portland District.*

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[Read 12th December, 1940; issued separately 26th July, 1941.]

Introduction.

Underlying the dune sands and dune limestones of the Portland District are extensive basalt flows and tuff beds which represent the western margin of the great Western District lava field of Victoria. These igneous rocks are part of the Newer Volcanic Series, and the lava flows, with a few exceptions, consist of iddingsite-labradorite-basalts of the Malmsbury and Footscray types (Edwards, 1938). The vents from which they were extruded fall into three groups (fig. 1).

The Coastal Volcanoes: Cape Bridgewater, Cape Nelson, Cape Grant, Lawrence Rocks, and Julia Percy Island.

The Central "Sand-covered" Volcanoes: Mt. Kincaid, Mt. Richmond, Mt. Clay.

The Northern Volcanoes: Moleside Creek vent, Mt. Vandyke, Mt. Deception, the group of vents at Mt. Eckersley, and Mt. Eccles.

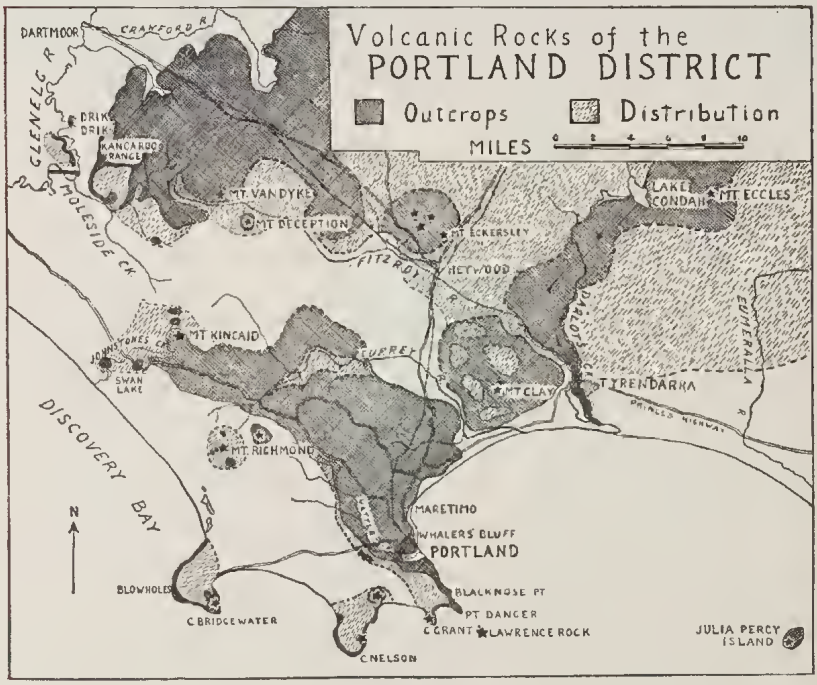

Fig. 1.

Difficulty was experienced in tracing some of the flows to their sources because of the change in texture of the rocks in the vicinity of the vents, and also because of the abundance of tuff associated with some of them.

Coastal Volcanoes.

Cape Bridgewater is a promontory composed of tuffs and basalt flows, overlain by dune sands and dune limestone. The steep eastern cliff-face, which rises to 450 feet above sea-level at the Stony Hill trig. station, provides a section through the composite volcano from which the igneous material came. As shown in fig. 2, two conduits connected with the surface flows of basalt are exposed, one between Bat Cave and Fisherman's Cave, and

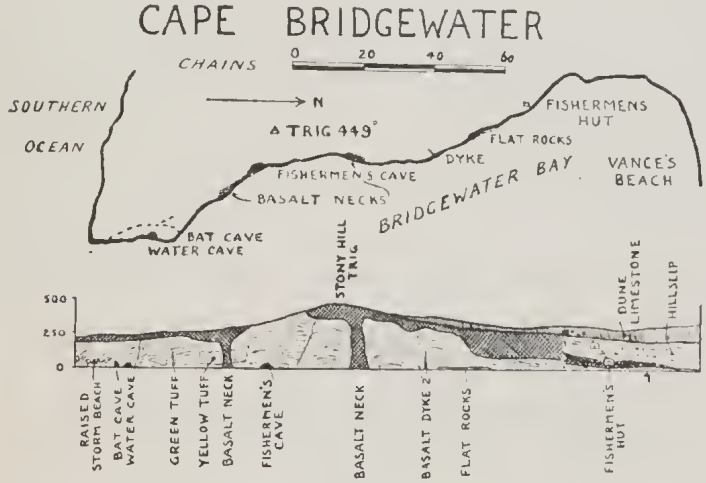

FIG. 2.

the other 30 chains east of Fisherman's Cave. The greater part of the cliff is formed by the undulating beds of tuff, containing scoria and lapilli, of the old volcanic cone. Numerous pebbles of Miocene limestone occur in the lower beds of tuff, but are found only occasionally in the higher beds; and masses of white and pink-stained quartz are embedded in the scoriaceous lava at the top of the vents. These fragments may have been detached from Palaeozoic sediments, which presumably underlie a cover of at least 2,000 feet of Tertiary limestone (as shown by the Portland bore), and probably a certain thickness of Jurassic sediments.

The basalt which was extruded from the more easterly vent, and forms Stony Hill, is dense and black, containing occasional phenocrysts of olivine. These are accompanied by microphenocrysts of labradorite (An_{60}) and diopsidic augite (2V greater than 45°), and are set in a microcrystalline groundmass of

pyroxene, iron ore, and felspar microlites. The augite tends to be glomeroporphyritic. The basalt from the westerly vent is dark grey, and minutely vesicular. It contains numerous phenocrysts of olivine, some very large, and occasional small laths of plagioclase (An_{60}). Some olivine crystals are unaltered, but others are almost entirely changed to iddingsite. The groundmass is very fine-grained, and consists of minute grains of pyroxene and olivine, felspar microlites, iron ore, and glass. A dyke 2 feet wide occurs at Cowrie Cove. It consists of tachylitic olivine-basalt.

The cliffs forming the western face of the Cape are composed of thick flows of basalt, separated by layers of scoriaceous basalt. Marine erosion has formed "blowholes" in places in the scoriaceous layers. The basalt is dark grey and dense, and consists of numerous microphenocrysts of olivine completely altered to iddingsite, and small laths of plagioclase (An_{60}) in a groundmass of plagioclase laths and abundant brown glass which has a "feathery" appearance owing to the presence of skeletal crystals of iron ore.

The basalt flows from the Cape Bridgewater vents are mostly covered by dune limestone.

Cape Nelson is another composite volcano whose structure is exposed in the cliff section facing Nelson Bay, between Black Bluff and Yellow Bluff (fig. 3). The cliffs rise sheer to a height

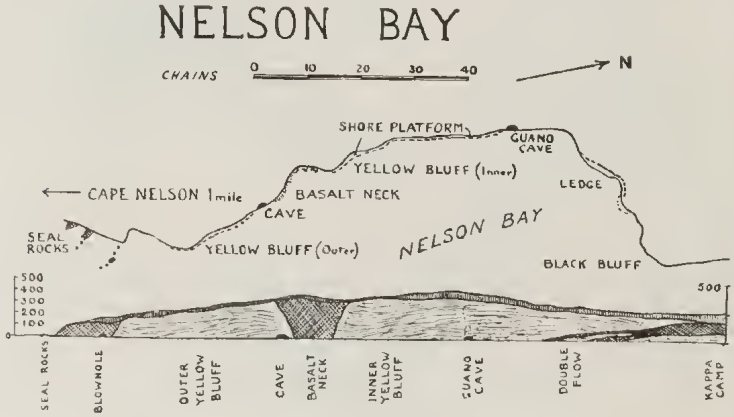

Fig. 3.

of 200–300 feet above sea-level, and are fronted by a narrow wave-cut bench. In the centre of the section is a funnel-shaped vent filled with scoriaceous basalt, and surrounded by beds of yellow tuff. The vent and the tuffs are capped with dune limestone.

At Black Bluff, low down in the projecting cliff face, there are two flows of basalt separated by about 4 feet of tuff. When followed eastwards, the upper flow, which is 5 feet thick, merges into the lower flow, which descends below water level. They are inaccessible, but what is probably the same flow increases in height to the east of Black Bluff, forming a single sheet of basalt about 50 feet thick near Kappa Camp, where it rests on 8 feet of tuff. Here the flow is an iddingsite-labradorite-basalt of the Malmsbury type. East of Kappa Camp, the basalt is cut off, presumably by a north-south fault, and the cliff consists of dune limestone down to sea-level.

This basalt probably had its source in the quarry reserve, Allotment 2, Section VII., Portland, where stone used for the Cape Nelson lighthouse was obtained. The basalt at the foot of the lighthouse (on the "Horseshoe") is also an iddingsite-labradorite-basalt of the Malmsbury type, and extends from the Seal Rocks at Yellow Bluff, to Old Shelly Beach on the west side of Cape Nelson. It is over 100 feet thick, and its base passes below sea-level. Patches of scoria occur in it, and it is overlain by dune limestone.

Cape Grant is of a similar nature. On its western side at "The Wells," four volcanic vents or necks are exposed in the cliffs (fig. 4) which are over 200 feet high. All four have walls of

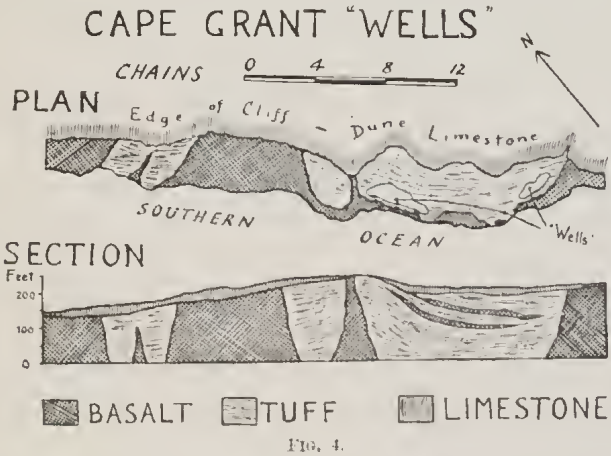

FIG. 4.

dense black basalt. The throats are filled with yellow tuff, scoria, blocks of basalt, and slightly metamorphosed blocks of Tertiary limestone. The largest vent, which is the most easterly, is 150 yards in diameter,

The material filling this vent is overlain by beds of scoria and thin irregular flows of basalt. The ash and scoria beds dip strongly westwards to the sea, indicating that the centre of the vent lies further inland, beneath the dune limestone.

The basalt forming the walls of these vents is dense and black. It consists of occasional microphenocrysts of olivine in part altered to serpentine, in a groundmass of abundant short laths and plates of zoned plagioclase (about Ab_{60}), aggregates of minute augite crystals, square grains of magnetite, and rods of ilmenite.

Lawrence Rocks, which are one mile off-shore from Point Danger and project about 80 feet above sea-level, have a basaltic foundation upon which rest beds of yellow tuff about 50 feet thick. Wave-cut benches up to 200 yards wide and 3 feet above water-level have been cut in the basalt.

Lady Julia Percy Island, 19 miles east of Portland, is a flat-topped island 120 feet high and one and a half miles in diameter, and is composed of boulder tuff, a series of olivine-labradorite-basalts, and iddingsite-labradorite-basalt of the Footscray type (Stach and McIver, 1936). The lava flows were derived from an adjacent vent, part of whose walls remain in the southern cliff of the island (Pinnacle Point).

The Central "Sand-Covered" Volcanoes.

The three domes of lava and tuff forming this group of volcanoes are covered not by dune limestone, but by younger sand dunes.

Mt. Kincaid, the most westerly of the three, rises to 664 feet above sea-level, and is covered by patches of dune sand to a height of 500 feet. The summit, which is free of sand, is composed of vesicular basalt. The flow from this volcano extends south-eastwards for 20 miles, as far as Portland. It is a vesicular, dark-grey, iddingsite-labradorite-basalt of the Malmsbury type. The olivine crystals are of two generations. The earlier-formed crystals occur as idiomorphic phenocrysts and are largely altered to iddingsite, while the later crystals, which belong to the groundmass, are only slightly iddingsitized, indicating that the iddingsitization occurred chiefly prior to the solidification of the lava. The flow averages about 100 feet in thickness, and passes below sea-level at Blacknose Point and Point Danger. Dune deposits occur only along its western margin.

It lies chiefly on Miocene limestone, but in the cliffs below "Maretimo" on the Dutton Way (North Portland), at Whaler's Bluff, and in places near Battery Point, an oyster bed, probably of Lower Pliocene age (Coulson, 1940) caps the limestones underneath the basalt. The undulations in the surface of the Miocene beds exposed in the cliffs between Battery Point and "Maretimo" cause the basalt to descend to sea-level nine times in this cliff section, with intervening places where the top of the Miocene is 40 feet above sea-level.

It may be noted that the numerous basalt boulders, up to a foot in diameter, brought up by divers working at the outer end of the long pier at Portland, are derived not from this flow, but apparently from the basalt of Lawrence Rocks. Boulders of this origin are associated with the basalt *in situ* along the beach from Battery Point to Pebbly Beach and Point Danger.

Mt. Richmond, 16 miles west of Portland, is a low broad dome covering an area of 5 square miles and rising to a height of 738 feet. The basalt, which is a fine-grained olivine basalt, is largely buried beneath a thick mantle of dune sands that reaches to the summit, and there do not appear to be any large flows away from the mount, although some may exist beneath the sand. The sands are arranged in a series of "tiers" encircling the volcano. The significance of this feature has been discussed elsewhere (Coulson, 1940).

Mt. Clay, 622 feet above sea-level, is another large dome rising above a basaltic plateau which is 400 feet above sea-level. It is a composite volcano, but all of its several vents extruded a similar variety of dense dark-grey olivine-basalt with a microcrystalline groundmass. A surface crust of vesicular basalt is present on the southern flanks. Large quantities of tuff were also ejected. A bore near the summit penetrated 130 feet in tuff. This tuff contains occasional blocks of chilled basalt.

On the southern slopes, at the Woolwash, the basalt formed a temporary barrier across the valley of the Surrey River. As a result the present valley of that river is constricted to a bottle-neck between Mt. Clay and the Gorae tongue of the Mt. Kincaid flow. Upstream from this point there has been a development of extensive alluvial flats at Heathmere and Heywood. At the base of the alluvium, there is almost everywhere a bed of buckshot gravel which averages 4 feet in thickness and rests directly on the eroded surface of the Miocene limestone. Near the Heathmere Railway Station a bore put down in 1894, in Allotment 2, Section VII., of Bolwarrah, by the Mines Department, passed through 7 feet of alluvium and buckshot, and then entered Tertiary limestone. It was still in Tertiary limestone at 1,505 feet, when it was abandoned.

The Mt. Clay basalt does not appear to pass below sea-level. Where its base is exposed it rests on the Tertiary limestones at about 60 feet above sea-level; and on the north side of the Mount, in Section 16, of Narrawong, tachylytic basalt rests on *Ditrupa* limestone (Miocene) at about 60 feet above river level.

The Northern Volcanoes.

Moleside Creek: Volcanic agglomerate outcrops in the great bend of the Glenelg River, near Moleside Creek. The outcrop extends for a mile in an east-west direction, crossing the river at three points, as shown on the geological parish plans of Kinkella and Kentbruck. Between and beyond these points it is

hidden under sand. The agglomerate consists of lapilli, fragments of metamorphosed Tertiary limestone, and fragments of slaggy basalt, which are cemented together by black, vesicular basaltic glass. It rises to a height of 60 feet above river level, and appears to have formed a barrier in the path of the Glenelg, so that it may have been a contributing factor to whatever caused the river to take its great westerly bend at this point. The agglomerate may infill a fissure.

On the south side of the Glenelg in the parish of Warrain, and close to its boundary with the parish of Kentbruck, a basalt dyke 4 feet wide has been noted by the Geological Survey. It is a much decomposed olivine-basalt.

On the west bank of the Glenelg, north of Moleside Creek, a flow of microporphyritic olivine-basalt about 5 feet thick occurs at the base of the dune limestones and sands, and overlies the Miocene limestones, which rise here to 100 feet above river level.

This rock appears to be identical with that capping the Kangaroo Range on the eastern bank of the Glenelg at a height of 400 feet. This similarity, and the difference in level of the two outcrops suggests that in this part of its course the Glenelg follows a north-south fault, as postulated by Foster (1929) in a section accompanying his geological map of the parish of Balrook, though this section does not agree with that drawn by Keble (1928) for the adjacent parish of Drik Drik to the north. Keble shows the "fault" as a cliff section. Foster based his section on the evidence obtainable at a large sink hole in Allotment 35, parish of Balrook. On the east side of the sinkhole, the Kangaroo Range basalt is exposed overlying Miocene limestone, while on the west side there is a boulder bed surmounted by dune limestone which dips at 30°N. and is about 55 feet thick. It rests unconformably on the boulder bed which is at least 20 feet thick. The boulders consist of sub-angular blocks of decomposed basalt, up to 12 inches in diameter, and angular blocks of Tertiary limestone up to 3 feet in diameter. The limestone is indurated, but does not appear to be volcanic ejectamenta. The blocks occur in a reddish-brown sand which contains only Miocene fossils. Mr. W. J. Parr has identified the following foraminifera from the sand:—

Dentalina inornata d'Orbigny.
Lagena sp. aff. *orbignyana* (Segeuza).
Globigerina bulloides d'Orbigny.
Globigerina dehiscens Chapman, Parr and Collins.
Cibicides sp.
Carpentaria rotaliformis Chapman and Crespin.
Elphidium crispum (Linné).
Operculina victoriensis Chapman and Parr.

Mr. Parr searched for, but failed to find, forms common to the dune limestone, such as *Discorbis dimidiatus*. Presumably, therefore, the boulder bed is a pre-dune-limestone talus at the

foot of a cliff of Miocene limestone surmounted by basalt. There is nothing to indicate whether it is talus from a river cliff or from a fault scarp. Exploration of a tunnel-like cave which connects this sinkhole with others 400 yards to the north, shed no light on this point. The cave is 30 feet high and 4 feet wide at the top, broadening to 10 feet at the bottom. A small underground stream runs through it. To the north the tunnel is in Miocene limestone, while to the south it is blocked by fallen blocks of Pleistocene dune limestone.

If the fault exists, as the levels of the basalt flows would indicate, it is presumably post-basaltic but pre-dune-limestone in age.

Mt. Vandyke (Good Hill) is a point of eruption 606 feet high. A flow of felspathic basalt issued from it, and spread out to the north and west for several miles. Its full extent is hidden by thick forest in the parish of Cobboboonee, but it appears to overlie the Kangaroo Range basalt. The rock is a dark-grey colour with abundant large white felspar and olivine phenocrysts, and bears some resemblance to the type of basalt forming the Stony Rises at Pirron Yallock (Skeats and James, 1937). A similar rock occurs at West Gorae, one and a half miles east of Mt. Richmond, in Allotment 15, Section 9, parish of Mouzie, where it forms a separate hill, probably a point of eruption, about 325 feet high. In this section it is an iddingsite-andesine-basalt of the Ballan Type (Edwards, 1938).

Mt. Deception (524 feet) is three miles east of Mt. Vandyke, and the Fitzroy River runs between them. Mt. Deception consists almost entirely of tuff with a few blocks of slaggy basalt. No flow could be traced from it.

The Mt. Eckersley Group of four volcanic hills comprising the Oakbank Estate, north-west of Heywood, shows considerable variation in the structure and composition of the several hills. Mt. Eckersley proper, or Bell's Hill (537 feet) is largely composed on tuff, which is well exposed in an old quarry near the summit. Occasional blocks of finely vesicular basalt occur in the tuff.

Sugarloaf Hill is composed of a grey compact iddingsite-basalt which is exposed in a quarry in Allotment 3, Section 3, parish of Drumborg. The third hill in Allotment 9, parish of Drumborg, north-west of Heywood Cemetery, is composed of a black, vesicular, fine-grained iddingsite-basalt, but the flow which issued from it to the west is not vesicular, and the olivine in it shows no trace of alteration to iddingsite. A coarser-grained iddingsite-basalt occurs in Allotment 7, Section 4, parish of Drumborg, immediately north-west of Heywood Cemetery.

The fourth hill, in Allotment 7, parish of Drumborg, consists chiefly of tuff with an occasional block of chilled basalt.

Mt. Eccles (584 feet) is probably the most recent point of eruption in the area. The flow from it filled a valley running to the sea, and divided the waters of the Fitzroy River and Darlot's Creek from Ettrick to Tyrendarra. In the vicinity of Tyrendarra and Homerton the infilled valley had been eroded in dune limestone (Hills, 1939; Coulson, 1940), so that this basalt is probably of Recent age. Throughout its length it has developed small stony rises and lava blisters, and numerous lava caves occur within it, similar to those described by Skeats and James (1937) in other parts of Western Victoria. In damming back Darlot's Creek, the flow gave rise to the Condah Swamp (Hills, 1939).

Conclusion.

From the foregoing brief descriptions, it will be seen that the basalts of the Portland District have undergone very little differentiation and are generally similar to the undifferentiated basalts of the Newer Volcanic Series elsewhere in Victoria. The eruptions which gave rise to them appear, however, to have produced a much greater amount of tuff than was developed in Central Victoria. In this respect they resembled the eruptions of the Colac-Camperdown District, where tuffs are equally abundant. The period of extrusion seems to have been of considerable duration, extending possibly from the Pliocene (Mt. Kincaid flow) through to the Recent (Mt. Eccles flow).

Acknowledgments.

My thanks are due to Messrs. W. J. Parr and F. S. Colliver for the identification of fossils; to Mr. G. B. Hope for the loan of instruments; to Messrs. F. E. Levy, W. C. Hedditch, B. O. Squire, and the Mines Department, for supplying maps; and to Dr. A. B. Edwards, for help with the petrography.

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